

FEDERAL HIGHWAY ADMINISTRATION

Long Term Pavement Performance

Colorado SPS-5

FORENSIC EVALUATION REPORT

January 1995

Prepared By:

**Western Region Coordination Office Contractor
Nichols Consulting Engineers, Chtd.**



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1885 S. Arlington Ave., Suite 111, Reno, Nevada 89509 Tel (702) 329-4955 Fax (702) 329-5098

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INTRODUCTION

Documented within this report is the history, the current status and forensic evaluation results for SPS-5 experimental test Site 080500 located on I-70 in eastern Colorado. Three site reviews have been performed and a forensic study was conducted. This LTPP experimental test site was constructed in October 1991. Construction methods, dates and materials are detailed in the Colorado SPS-5 Construction Report on SHRP 080500, October 1994, developed by Nichols Consulting Engineers. The test site consists of eleven test sections, as shown in Figure 1.

Four different mix designs were used throughout the project as surface mixtures. The standard LTPP experiment has a virgin AC mixture and a 30% recycled mixture. In addition to these two mixes, this project has a polymer modified mix (Section 080560) and a rut level-up mixture on Section 080501.

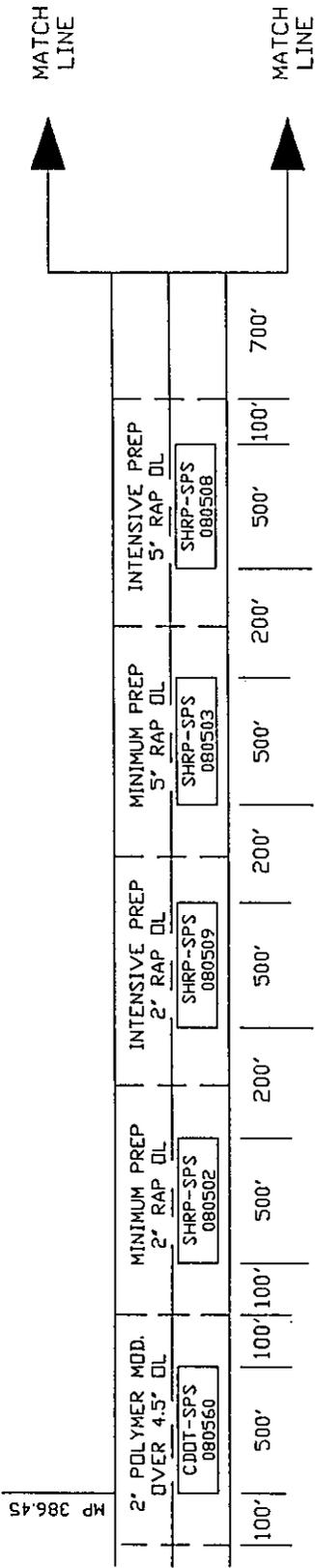
SITE REVIEWS

The first site review was performed in late September 1994 by the Western Region Tour Group. The group consensus was that all mixes generally were dry, with early hardening, loss of fines, the construction joint was generally poorly compacted and was open and raveling. The group recommended sealing as soon as possible. Segregation of the mix was sporadic throughout the test sections. Deflection data showed no differences between sections of very different structures, clay balls were evident throughout all sections. The group stated a materials analysis should be conducted to evaluate the reasons for early aging. They suggested strategies be developed for preventative maintenance and a forensic analysis be conducted using cores, looking at stability, asphalt content, stripping, gradation, voids, density, etc. The complete site report detailing the section-by-section review is contained in Appendix A.

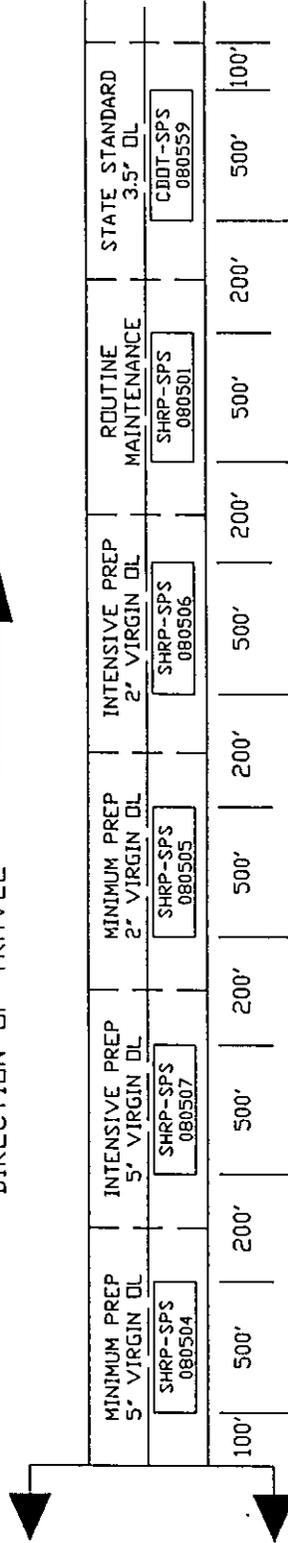
On June 8, 1994, this site was again reviewed by Ahmad Ardani (CDOT) and Doug Frith (NCE), both of which were present for the first site review. As in the previous site evaluation, the primary distress noted was raveling of the surfacing. It was the reviewers opinion that the raveling in the polymer modified mixture was not as severe as the virgin or recycled AC which both appeared to be comparable. Several sections were showing reflection cracking from the underlying layers, as well as fatigue cracking. The major distress in all sections was the centerline (paving) joint. The joint was diminishing rapidly due to a poor construction joint which was stripping and raveling, losing both fine and coarse aggregate. In some locations, the centerline joint was as much as 50mm (2 in.) wide at the surface. The reviewers concluded the surface raveling was not increasing rapidly, although there were isolated pockets with moderate severity raveling. A problem with the center of the paver was becoming very apparent by a crack, which was starting to ravel, noted at the center of the paving pass within several test sections.

SPS-5 TEST SECTION LAYOUT
 0805, EAST OF LIMON, COLORADO
 I-70 EASTBOUND

03/15/94



DIRECTION OF TRAVEL →



NOT TO SCALE

A third site review was conducted October 14, 1994. This site review was billed as the forensic evaluation review. Representatives from NCE, PCS/LAW, and CDOT were involved. In reviewing the site, several things were noted which could have an adverse impact on "normal" (expected) performance deterioration. Essentially, the asphalt surface appeared to have numerous locations where segregation occurred during laydown. In addition, the surface appeared to have been losing the fine aggregate portion of the asphalt mixture, exposing the coarse aggregate more than expected for a pavement of relatively recent construction. The areas of segregation will eventually result in high severity raveling and formation of potholes. The loss of fines will also result in raveling, but over a wider area. The construction joints were in very poor condition in many of the sections, in some cases opened to 50mm (2 in.) or more.

MAINTENANCE STRATEGY

During the forensic evaluation review, the site conditions and potential maintenance approaches were discussed in the field. CDOT and local district staff were enthusiastic in wanting to keep the SPS-5 project in acceptable condition, i.e., they did not want to perform any maintenance activity which would result in the project not meeting experiment requirements. At the same time, they did not want to allow this section of highway to deteriorate too much, resulting in an expensive fix. They did have maintenance budget sufficient to perform crack filling and periodic fog sealing to attempt to offset the loss of fine aggregate.

A consensus was reached among the CDOT personnel resulting in the following:

- Crack filling will be performed during the Fall 1994
- A fog seal will exceed current budget and schedule limitations, but effort will be made to apply a seal, Summer 1995
- CDOT will continue to keep WRCOC informed of activities affecting this project and maintenance activities will be reported using the appropriate data forms provided to CDOT by WRCOC

FORENSIC EVALUATION

During the forensic evaluation review, it was decided to extract a few cores from the test sections to verify the appearance and depth of the stripping. The coring was performed by CDOT October 24, 1994. Pete Pradere, representing NCE, was also present. Appendix B contains the complete report and photos as developed by Pete Pradere. Conclusions based upon the coring operation are:

- (1) the visual appearance indicates distress more severe than actual in-pavement conditions,
- (2) it appears the distresses are occurring on the surface and propagating deeper into the mix, and

- (3) results from the coring support the proposed maintenance strategies if they are applied in a timely manner.

CONCLUSIONS

Based upon the visual condition of the test sections and the results of the coring operation, the proposed maintenance procedures should significantly prolong the life of this pavement, thus maintaining its effectiveness in the LTPP experimental study.

APPENDIX A

SITE REVIEW REPORTS

COLORADO

SPS-5 Limon (I-70EB)

Generally dry mix, early hardening, loss of fines, construction joint is generally poorly compacted and is open or raveling, recommend sealing ASAP. Segregation of mix sporadic throughout the test sections. Deflection data shows no differences between sections of very different structure. Should be a materials analysis conducted on these sections to evaluate the reasons for early aging. Clay balls were evident throughout all the test sections.

Strategies should be developed for preventative maintenance. Forensic analysis should be conducted using cores, looking at stability, AC, Stripping, gradation, void, density, etc.

2" Polymer Modified over 4" Conventional AC (080511)

Remarks

Slight abrasion (raveling) throughout most of section. Construction joint is open and raveled. Surface appears weathered and older than two years. Remaining life approximately 1-2 years before sealing joint and possibly surface treatment to hold fines in place.

Minimum Preparation 2" Recycled Overlay (080502)

Remarks

Abrasion (raveling) throughout but numerous occurrences of sandy material (fat spots). Some minor fatigue cracking noted at end of the section. Recommend fog seal now to preserve fines in surface then rehab at 5 years.

Intensive Preparation 2" Recycled Overlay (080509)

Remarks

Abrasion (raveling) throughout but numerous occurrences of sandy material (fat spots). Some minor fatigue cracking noted at end of the section. Recommend fog seal now to preserve fines in surface then rehab at 5 years.

Minimum Preparation 5 "Recycled (080503)

Remarks

Minor abrasion and loss of fines. The mix is extremely dry looking. Minor traffic densification in the wheel path. Some mix segregation noted. Clayballs were observed throughout the section. The centerline construction joint is raveling and is in need of immediate maintenance. Sandy fat spots throughout section. A forensic investigation should be conducted to determine the reason for the excessive aging of the pavement.

Intensive Preparation 5" Recycled (080508)

Remarks

Minor abrasion and loss of fines. The mix is extremely dry looking. Minor traffic densification in the wheel path. Some mix segregation noted. Clayballs were observed throughout the section. The centerline construction joint is raveling and is in need of immediate maintenance. Sandy fat spots throughout section. A forensic investigation should be conducted to determine the reason for the excessive aging of the pavement.

Minimum Preparation 5" Virgin AC (080504)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

Intensive Preparation 5" Virgin AC (080507)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

Minimum Preparation 2" Virgin AC (080505)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

Intensive Preparation 2 " Virgin AC (080506)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots

throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

Routine Maintenance (080501)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

State Standard 3" Overlay (080510)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.



DATE: June 8, 1994
TO: Jim Nichols, Cal Berge, Pete Pradere
FROM: Doug Frith (DJF)
SUBJECT: Summary of Site Review on Colorado SPS-5

File: 800.12.4.9.10
080500

May 26, 1994 Ahmad Ardani and Doug Frith performed a site review of the SPS-5 section near Limon, Colorado. As time was short, the review was performed from the shoulder of the roadway without traffic control. As noted from a previous review, the primary distress type noted is raveling (loss of fines) of the AC surfacing.

Three different types of surfacing are present on this site, a polymer modified overlay, the virgin AC overlay and the 30% recycled AC overlay. Although each of these products exhibited surface raveling, the polymer modified was not as severe as the virgin or recycled AC, which both appeared to be comparable. A detailed section-by-section review was not performed, however each type of material was closely reviewed.

Several sections are showing the reflection cracking from the underlying layers as well as fatigue cracking. The major distress in all sections is the centerline (paving) joint. This joint is diminishing rapidly due to a poor construction joint which is stripping out, losing of both fine and coarse aggregate. In some locations, this centerline joint is as much as four inches wide at the surface.

After reviewing this section with the SPS tour last fall, I do not believe the surface raveling has increased rapidly, although there are isolated pockets with moderate severity raveling. A problem with the center of the paver is also very noticeable by a crack, which is starting to ravel, noted at the center of the paving pass within several sections.

It is my opinion that some form of maintenance must be performed on this section, otherwise we will see a premature failure due to mixture and construction related problems which will dilute the effectiveness of this section. I would recommend that the centerline joint be sealed with a sand seal or patched with AC and the entire surface receive some type of seal coat, such as a chip seal, slurry seal or sand seal. I would also recommend a meeting similar to the one held for the California SPS-6 be held in Colorado.

PCS/LAW ENGINEERING
(A Division of Law Engineering, Inc.)
12104 Indian Creek Court, Suite A
Beltsville, Maryland 20705-1242
FON 301-210-5105 -- FAX 301-210-5032

MEMORANDUM

October 17, 1994

To: Monte Symons

From: John Miller

Subject: SPS-5 CO Site Visit

cc: Cal Berge, Doug Frith, Pete Pradere, Gonzalo Rada

This memorandum will briefly summarize the findings and resulting action items from the site visit to the SPS-5 project on I-70 near Limon Colorado. The visit was conducted by representatives from the western regional coordinating contractor, the LTPP technical assistance contractor and a number of CDOT personnel.

The visit consisted of a site review on the morning of Thursday October 14 followed by a meeting held that afternoon.

In reviewing the site several things were noted which could have an adverse impact on "normal" (expected) performance deterioration. Essentially, the asphalt surface appeared to have numerous locations where segregation occurred during laydown. In addition, the surface appeared to have been losing the fine aggregate portion of the asphalt mixture, exposing the coarse aggregate more than expected for a pavement of relatively recent construction. The areas of segregation will eventually result in high severity raveling and formation of potholes. The loss of fines will also result in raveling, but over a wider area. The construction joints were in very poor condition in many of the sections, in some cases opened to 50 mm or more.

The site conditions and potential maintenance approaches were discussed in the field. CDOT and local district staff are enthusiastic in wanting to keep the SPS-5 project in acceptable condition, i.e., they do not want to perform any maintenance activity which would result in the project not meeting experiment requirements. At the same time, they do not want to allow this section of highway to deteriorate too much, resulting in an expensive fix. They do have maintenance budget sufficient to perform crack filling and periodic fog seal to attempt to offset the loss of fine aggregate.

The LTPP TAC representative assured the CDOT personnel that surface treatments (non-structural) would not violate the experiment requirements. It was made clear to the CDOT

Mr. Monte Symons
SPS-6 CA Visit
Page 2

personnel that the highway is their responsibility and that whatever maintenance activity may be needed was up to them.

A consensus was reached among the CDOT personnel resulting in the following:

1. Crack filling will be performed this year.
2. A fog seal will exceed current budget and schedule limitations but effort will be made to apply a seal, hopefully next summer.
3. CDOT will continue to keep WRCO informed of activities affecting this project and maintenance activities will be reported using the appropriate data forms provided to CDOT by WRCO.

APPENDIX B

FIELD EVALUATION & CORING OPERATION REPORT

COLORADO SPS5

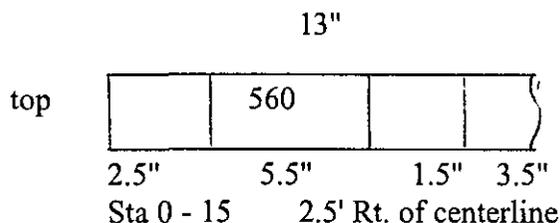
FIELD EVALUATION OF EXISTING PAVEMENT
CONDITION AND CORE VISUAL EVALUATION

080560

This is a State supplementary section. There is a considerable loss of fines in the surface throughout the section and some minor loss of the coarse aggregate. There is raveling and cracking at centerline. There was some cracking in the left wheelpath near 3+00. The passing lane showed more raveling than the travel lane. Some of the loss of coarse aggregate appeared to be caused by soft degradable material.

Photo
1 - 1
thru
1 - 9

Core 560 is in good condition. There was not any damage incurred drilling the core, however there was a fair amount of asphalt floating on the drilling water which may indicate a water sensitivity problem.



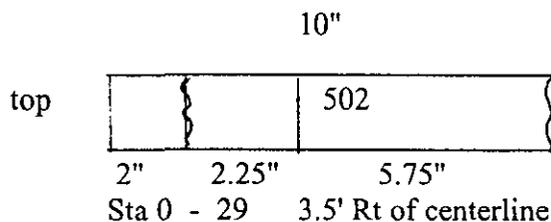
Note: Only readily identifiable lifts are shown.

080502

This is the first SHRP section on the project. There is considerable loss of fines at the beginning of the section and this decreased somewhat near the end of the section. There was raveling at the centerline joint throughout the section. There was midlane cracking near 2+20. Near the end of the section there were some random fat spots of asphalt on the surface. These were 3" to 6" blots.

Photo
1 - 9
thru
1 - 17

Core 502 broke apart 2" from the top debonding at a lift joint. There was minor fines loss due to drilling in the top 2" and at the lift joint, however the rest of the core did not show any visual loss. There was free asphalt floating on the drilling water.

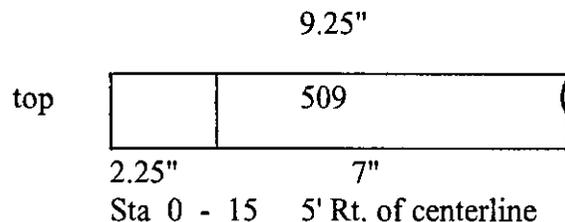


Note : There is a badly cracked area (3" alligator) 100' past the end of this section in the right wheelpath approximately 4' wide and 6' long. It has indications of pumping and is dished in the middle which leads you to believe this may be a subgrade failure. A core was not taken in this area as it may lead to potholing and we did not have mix to repair an area this big. Photo 1 - 18

080509 There is moderate loss of fines on the surface throughout this section. There is severe raveling at the centerline joint and some raveling at midlane within the first 200' of the section. There was considerably more distress in the passing lane near the end of the section.

Photo
1 - 19
thru
1 - 25

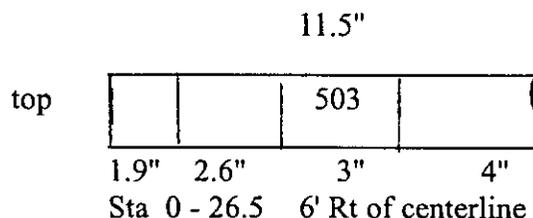
Core 509 was taken at the edge of a crack. There was moderate loss of material along the edge of the crack down to the lift interface (2.25"). The remainder of the core did not show any distress or loss of material due to coring. There was free asphalt floating on the drilling water.



080503 This section has experienced only minor loss of surface fines. The raveling at the centerline joint is considerably less severe and there is some distress at midlane near 1 + 00 which shows raveling and cracking.

Photo
1 - 26
thru
1 - 30

Core 503 showed a very minor loss of fines at the top lift interface. The rest of the core did not show any distress, however there was free asphalt on the drilling water.

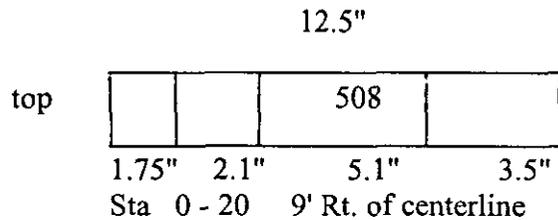


080508 This section shows very little distress. the surface shows some minor loss of fines. There is more loss of fines 1' to 2' lt. and rt. of centerline than in the rest of the section. There is minor raveling at the centerline joint.

Photo
1 - 31
thru
1 - 33

There is a 4' wide by 11' long area in the right wheelpath which appears to have been a construction problem and shows some surface irregularities.

Core 508 did not indicate any distress. There was free asphalt on the drilling water.

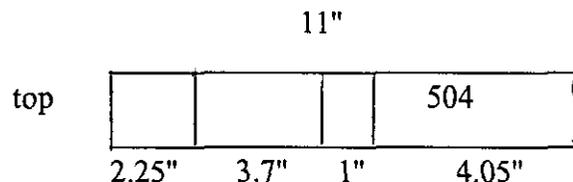


080504

There was minor loss of fines in the surface of this section. There was some cracking in the left wheelpath at the 1+05 and at midlane near the end of the section. There was little raveling at the centerline joint. There were some random fat spots of asphalt on the surface.

Photo
1 - 34
thru
1 - 37

Core 504 showed some minor loss of material at the interface 3.85" below the top surface. There was not any other distress in the core. There was free asphalt on the drilling water.

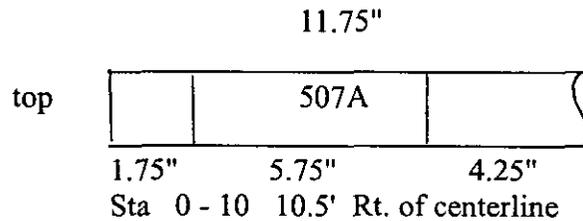
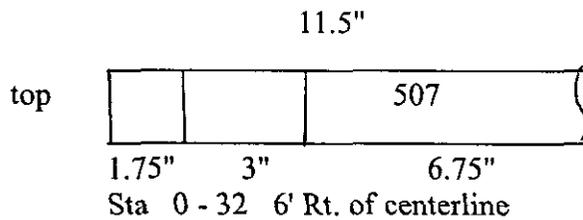


080507

This section shows moderate loss of fines throughout the section. There is some loss of large aggregate, however this appears to be caused by soft and degradable material. There is moderate raveling at the centerline joint and there is some raveling and cracking at midlane. There is some minor longitudinal cracking in the right wheelpath.

Photo
2 - 1
thru
2 - 12

Two cores were taken from this section to compare distress levels. Core 507 was taken from a midlane raveled and cracked area. There was distress in the top lift of this core only. The crack does not extend into the second lift of plantmix. There was loss of material in the top lift, however the core remained in tact. There was free asphalt on the drilling water. Core 507A was taken in the right wheel path in what appeared to be a severely cracked and raveled area. This core showed loss of material in the top lift and minor fines loss in the rest of the core. the cracking and raveling is limited to the top lift and does not extend below it. There was free asphalt on the drilling water.

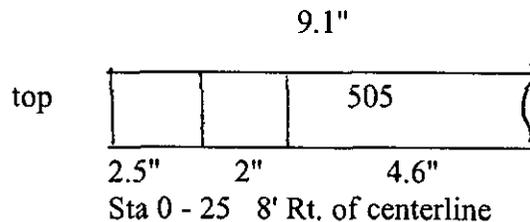


080505

The surface of this section shows medium fines loss. There are several random 3' to 5' length cracked areas. There is medium raveling at the centerline joint. There were some random fat spots of asphalt on the surface.

Photo
2 - 13
thru
2 - 20

Core 505 was taken over a fairly wide crack. The top 2.5" lift fell apart and a piece of the next lift to a 1.5" depth also broke apart. There was considerable material loss in the top lift and some fines loss down to 4.5", however there was little damage to the rest of the core except for the broken area. There was free asphalt on the drilling water.

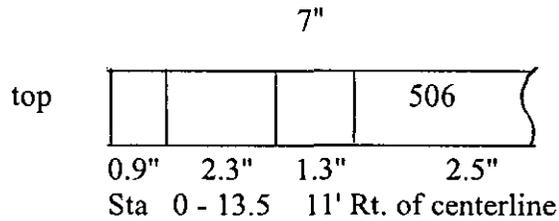


080506

There is a considerable loss of fines in the surface. There is heavy raveling in the centerline joint and some raveling and cracking at midlane throughout the section.

Photo
2 - 21
thru
2 - 25

Core 506 was taken from the right edge of the lane where raveling was more sever. There was loss of fines in the top 1" and a minor loss of fines in the bottom lift. There was free asphalt on the drilling water.

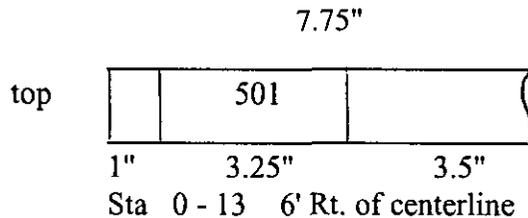


080501

There is only minor loss of fines in the surface of this section. The raveling at the centerline joint is less than other sections. There are some random transverse cracks 3' to 5' in length in the last 150' of this section. There appears to be some light rutting (.25" to .5") in the left wheelpath.

Photo
3 - 1
thru
3 - 4

Core 501 shows no distresses. There was free asphalt on the drilling water.

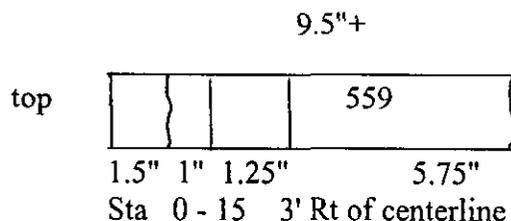


080559

There was some loss of fines in the surface. There was cracking and raveling in the right wheelpath at the beginning of the section only. There was some minor raveling at midlane and raveling at the centerline joint from 2 + 90 to the end of the section. There were random asphalt fat spots throughout the section. There is minor rutting in both wheelpaths (.25").

Photo
3 - 5
thru
3 - 10

Core 559 was taken from a crack in the left wheelpath. The entire length of the core could not be retrieved. It was drilled to a depth to 18", the core barrel length, however this did not reach the total depth and the core broke at 9.5" after considerable effort was made trying to lift the core out. The top 1.5" delaminated and broke apart. The crack extended 2.5" in the core. Visual observation of the core hole showed the crack is propagating from the top down into the lower layers. There was not any free asphalt in the drilling water.



SUMMARY

This project is three years old. The surface of all sections appears aged, dry, and brittle. There is loss of fines in the surface throughout all test sections. There is cracking and raveling of the centerline joint and at midlane in almost all sections. There is cracking both longitudinal and transverse to varying degrees in most of the sections.

All of the above distresses appear to be related to a moisture sensitive mix. The stripping of the asphalt during the core drilling tends to substantiate this. The visual appearance indicates distresses more severe than actual condition. From the core evaluations it appears the distresses are occurring at the surface and propagating deeper into the mix. At this time it appears the majority of the distresses are located in the top 1.5" of the mix and only this deep in areas where moisture can penetrate; such as cracks and the raveled centerline joint.

A meeting was held with personnel from Colorado DOT, PCS Law, and NCE prior to coring this project. At this meeting CDOT recommended sealing all cracks and raveled joints this fall and placing a sand seal on the entire surface next spring. The cores from this project support this maintenance strategy and if it can be accomplished in a timely fashion should reduce the deterioration of this project considerably.



PIERRE F. PRADERE P.E.

PHOTOLOG COLORADO SPS 5
CORE EVALUATION

TEST SECTION	PHOTO	DESCRIPTION
080560	1-1	Begin section looking east
	1-2	Surface condition at beginning of section
	1-3	Core drilling
	1-4	Core drilling with free asphalt on water
	1-5	Core drilling with core still in place
	1-6	Core 560
	1-7	Raveled areas in passing lane
	1-8	3+00 looking east - distressed area in wheelpath
080502	1-9	Beginning of section looking east
	1-10	Core hole with broken core
	1-11	Core hole with broken core
	1-12	Core 502
	1-13	Centerline joint raveling
	1-14	Closeup of centerline joint raveling
	1-15	2+20 looking east - midlane raveling and cracking
	1-16	Fat spots of asphalt on surface
	1-17	Closeup of fat spots
	1-18	Dished failure 100' past end of section
080509	1-19	Beginning of section looking east
	1-20	Core hole and core with free asphalt on water
	1-21	Core 509
	1-22	Closeup core 509
	1-23	Centerline joint raveling
	1-24	Centerline joint raveling
	1-25	Distress in passing lane near the end of the section
080503	1-26	Beginning of section looking east
	1-27	Core 503
	1-28	Core 503
	1-29	Distress near 1+00
	1-30	Distress near 1+00
080508	1-31	Beginning of section looking east
	1-32	Core 508

	1-33	Distressed area 1+40
080504	1-34	Beginning of section looking east
	1-35	Core 504
	1-36	Cracking at 1+05
	1-37	Cracking at midlane 4+70 to end of section
080507	2-1	Coring on a crack
	2-2	Beginning of section looking east
	2-3	Core 507 top
	2-4	Core 507
	2-5	Core 507
	2-6	Core 507
	2-7	Coring core 507A
	2-8	Core 507A top
	2-9	Core 507A
	2-10	Core 507A
	2-11	Raveling rt. wheelpath around 1+00
	2-12	1+70 Cracking and raveling
080505	2-13	Coring cracked area
	2-14	Core 505
	2-15	Closeup of core 505
	2-16	Closeup of core 505
	2-17	Close up of core 505
	2-18	Core hole on a crack
	2-19	Core hole on a crack
	2-20	Crack with some pumping
080506	2-21	Coring distressed area
	2-22	Core 506 top
	2-23	Core 506
	2-24	1+00 looking east
	2-25	3+70 looking east
080501	3-1	Beginning of section looking east
	3-2	Core 501 top
	3-3	Core 501
	3-4	1+30 looking east rutting lt. wheelpath
080559	3-5	Beginning of section looking east
	3-6	Coring on crack
	3-7	Core 559 top
	3-8	Core 509
	3-9	Core 509
	3-10	Random fat spots of asphalt on the surface